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ENGINEERING OF LOW-WASTE TECHNOLOGY OF NATURAL AND WASTEWATERS DEMINERALIZATION

Annotation

There is a significant problem of water pollution today, which is caused by the sharp increase in water mineralization in surface water bodies, especially in the industrial densely populated regions. Increased mineralization results from the discharge of insufficiently treated mine and industrial wastewater. Highly efficient water desalination processes are exploited to tackle this challenge in the industry, public utilities, and everyday life. First and foremost, these are baromembrane processes such as reverse osmosis and nanofiltration. At present, there are great prospects for the application of nanofiltration membranes in water treatment systems. Large-scale application of membrane technologies requires the simplification and reduction of the cost of water purification technologies, increasing their reliability and efficiency. There are two challenges that have to be tackled before the widespread application of the processes mentioned above. First of all, the processes of efficient lightening and bleaching of water have to be studied. Secondly, one has to cope with the problem of stabilizing water treatment before the membrane cleaning stage that is necessary for the prevention of sedimentation on the membranes.

A method that can effectively desalinate water is developed in this paper. Also, this method can solve the problem of water demineralization. With nanofiltration desalination and permissible chloride levels in the water, sulfates and rigidity ions are the only substances accumulated in the concentrate, which enables them to be further processed by reagent methods of precipitation in the form of calcium hydroxosulfoaluminates. A method of stabilization treatment of solutions is developed to improve the efficiency of the process and increase the membrane lifetime. A technological scheme of desalination of mineralized waters, which makes it possible to receive purified water at full processing of the generated waste into target products, is given in the paper.

Key words: *mineralized water; nanofiltration; reagent method; sediment; technological scheme of desalination*

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СТВОРЕННЯ МАЛОВІДХОДНОЇ ТЕХНОЛОГІЇ ДЕМІНЕРАЛІЗАЦІЇ ПРИРОДНИХ ТА СТІЧНИХ ВОД

Анотація

На сьогоднішній день досить гостро стоять проблеми забруднення водних об'єктів, що викликано різким підвищенням мінералізації води в поверхневих водоймах, особливо це стосується промислових густозаселених регіонів. Підвищення мінералізації відбувається внаслідок скиду недостатньо очищених шахтних та промислових стічних вод. Для вирішення даної проблеми в промисловості, комунальних господарствах та побуті використовуються високоефективні процеси знесолення води – баромембранні процеси, такі як зворотній осмос та нанофільтрування. Наразі нанофільтраційні мембрани мають величезні перспективи при застосуванні їх у системах підготовки води. Для широкомасштабного застосування мембранних технологій необхідно спрощення і здешевлення технологій очищення води, підвищення їх надійності та ефективності. Для широкого впровадження даних процесів необхідно вивчити процеси ефективного освітлення та знебарвлення води та вирішити проблему стабілізаційної обробки води перед стадією мембранного очищення, для запобігання осадовідкладенням на мембранах. В роботі для вирішення проблеми демінералізації води розроблено метод, що дозволяє ефективно знесолювати воду. При нанофільтраційному знесоленні в концентраті накопичуються лише сульфати та іони жорсткості, при допустимих рівнях хлоридів у воді, це дає можливість їх подальшої переробки реагентними методами з висадженням у вигляді гідроксосульфоалюмінатів кальцію. Для підвищення ефективності процесу та збільшення терміну експлуатації мембран розроблено метод стабілізаційної обробки розчинів. Запропонована технологічна схема опріснення мінералізованих вод, що дозволяє отримувати очищену воду при повній переробці утворених відходів у цільові продукти.

Ключові слова: *мінералізовані води; нанофільтрація; реагентний метод; осад; технологічна схема знесолення*

1. Formulation of the problem.

Today, the issue of water treatment is urgent, as the demand for both the high-quality drinking water for the population and the technical water for the industry is constantly increasing in the context of the limited clean water resources. One of the main sources of pollution and clogging of reservoirs is the discharge of insufficiently treated wastewater from the industrial and municipal enterprises.

Based on environmental safety requirements, all mineralized water is subject to unconditional desalination before discharge into open water bodies. Desalination of natural mineralized waters can also solve the problem of providing the drinking water to the population of the southern regions of Ukraine, in particular, in the face of extreme situations.

This paper presents the results of a study on the complex purification of highly mineralized water. The paper shows that it is necessary to ensure the proper efficiency of water desalination, as well as to develop methods of processing solid and liquid concentrated waste to obtain useful products. Only in this case is it possible to implement environmentally safe industrial water consumption.

The purpose of the work is to create complex waste-free technologies of purification of natural and waste saltwater for ecologically safe water systems.

2. Statement of the main research material

The membrane methods have been increasingly used for water desalination recently. It is known that the efficiency of baromembrane desalination depends largely on the quality of its pre-treatment. In the stabilization treatment of the model solution on a weakly acidic cation there can be observed reduction of the weakly acidic cation level to pH to 3.7, reduction of alkalinity to 0.0 mg-eq/dm^3, increase in acidity to 0.4 mg-eq/dm^3 and reduction of the stiffness to 8.6 mg-eq/dm^3; the parameters of chloride and sulfate concentrations don't change.

In the process of filtering, the resulting solution through the nanofiltration membrane OPMN − P, the change in membrane productivity, depending on both the working pressure and the degree of permeate selection, is determined. The productivity of the membrane increases with a rise of working pressure from 0.3 to 0.4 MPa and decreases with an increase in the degree of selection of permeate from 10 to 70%. This effect is due to the increase of salt content in the concentrate and the increase in osmotic pressure.

When acidified with water, the residual chloride concentrations in the permeate remain unchanged. They are of the same level as in the original solution and concentrate. Residual concentrations of sulfates and rigidity ions increase with the rise of permittivity and are virtually independent of operating pressure within 0.35 MPa. In this case, the selectivity of the membrane for chlorides is zero, as for the untreated solution, the sulfate is 72–76%, the rigidity ions 57–70%, which is 22–32% lower than the untreated solution. In this case, the acidification of water impacted the extent of the electrokinetic potential of the membrane surface and led to the destruction of the hydration shell on both the membrane surface and the surface of the membrane pores. Besides, changing the pH of the medium can impact the state of the hydrated shells of sulfate anions and stiffness cations. All this together leads to a certain decrease in the selectivity of the membrane and two charge ions.

In the process of the desalination of the solution after acid treatment, an increase to 26.5 mg-eq/dm^3 at a stiffness of 11.8–16.1 mg-eq/dm^3 in the content of sulfates in the concentrate is observed. Acidity doesn't exceed 0.27 mg-eq/dm^3. The chloride content is 3.0 mg-eq/dm^3. It is the same as in the original solution.

Purification of these concentrates is advisable to carry out due to the reagent softening of the solutions and the removal of sulfates to admissible standards. This allows solving the problem of desalination of concentrates after nanofiltration treatment of mine waters with a high content of sulfates and hardness ions.

The conditions of effective softening of solutions and purification from sulphates in complex treatment with lime and aluminum coagulants under the conditions of the least secondary contamination by chloride anions are determined in the paper.

The essence of the method is that by choosing the ratio between sodium hydroxoaluminate and aluminum hydrochloride, it is possible to adjust the content of purified water of chlorides and sodium ions when making the required amount of aluminum component (hydroxoaluminate) necessary for effective binding. In the alkaline environment, aluminum hydroxochlorideis converted to calcium hydroxoaluminate, which contributes to the efficiency of sulfate purification by co-precipitation of sulfate and calcium hydroxoaluminate. This contributes to both the increase in the efficiency of sulfate removal and the softening of water and the reduction in the pH of the medium without the use of carbon dioxide.

In the paper [1, p.70].it was shown that the concentration of sulfates can be reduced to 30 mg-eq/dm^3 with the help of lime; the stiffness of the solution was 24.0 mg-eq/dm^3. So, particularly this concentration was taken as the initial in further studies. In this case, the solutions after treatment with lime and aluminum coagulants were not treated with carbon dioxide. That is, the process was reduced by at least 2 stages (bubbling and filtration). At the same time, there was neutralization of alkali formed during hydrolysis of sodium hydroxoaluminate with hydrochloric acid, which was formed, in turn, in the process of hydrolysis of aluminum hydrochloride. In addition to the extraction of sulfates, there was a decrease in total mineralization from 2200 mg/dm^3 to extent less than 1000 mg/dm^3. Water softening was quite effective. The softening efficiency increased as lime consumption decreased. Alkalinity was also within acceptable limits. Such water can be discharged into the sewage system or reused during the water treatment process.

Experimental data confirm that sediments resulting from water purification can be used in cement as an expanding additive to compensate for the settling of cement and as an activator of curing slag Portland cement [2, p.105].

One of the options for the implementation of the developed processes is a schematic technological scheme of wastewater and concentrates treatment with complete recycling of the resulting waste. The scheme provides for baromembrane water desalination. After the aerator, the mineralized water (concentrate) enters the reaction chamber where lime, sodium aluminate, and aluminum hydrochloride are dispensed. This process provides deep water softening to 3.0–1.3 mg-eq/dm^3 and sulfate extraction to 1.7 mg-eq/dm^3. After the sump, softened water along with its lightening and discoloration is got. The sediment, formed during the desalination process, is separated and utilized for processing as an expanding additive for cement and a sulfate activator for slag Portland cement.

3. Conclusions

For the widespread implementation of low-waste water treatment technologies in the production and efficient operation of, the following tasks have been fulfilled in the paper:

- the methods for processing baromembrane water purification concentrates, aimed at creating low-waste water demineralization technologies, have been developed;
- the technological scheme of complex treatment of mineralized water, which makes it possible to create low-waste technologies for desalination of these waters with complete treatment of the waste, has been developed and proposed.

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